Pan-Planets

Searching for Hot Jupiters around Cool Stars

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Overview

Exoplanet Theory

Project Properties

Monte-Carlo Transit Injections

Candidates

OVERVIEW

EXOPLANET THEORY

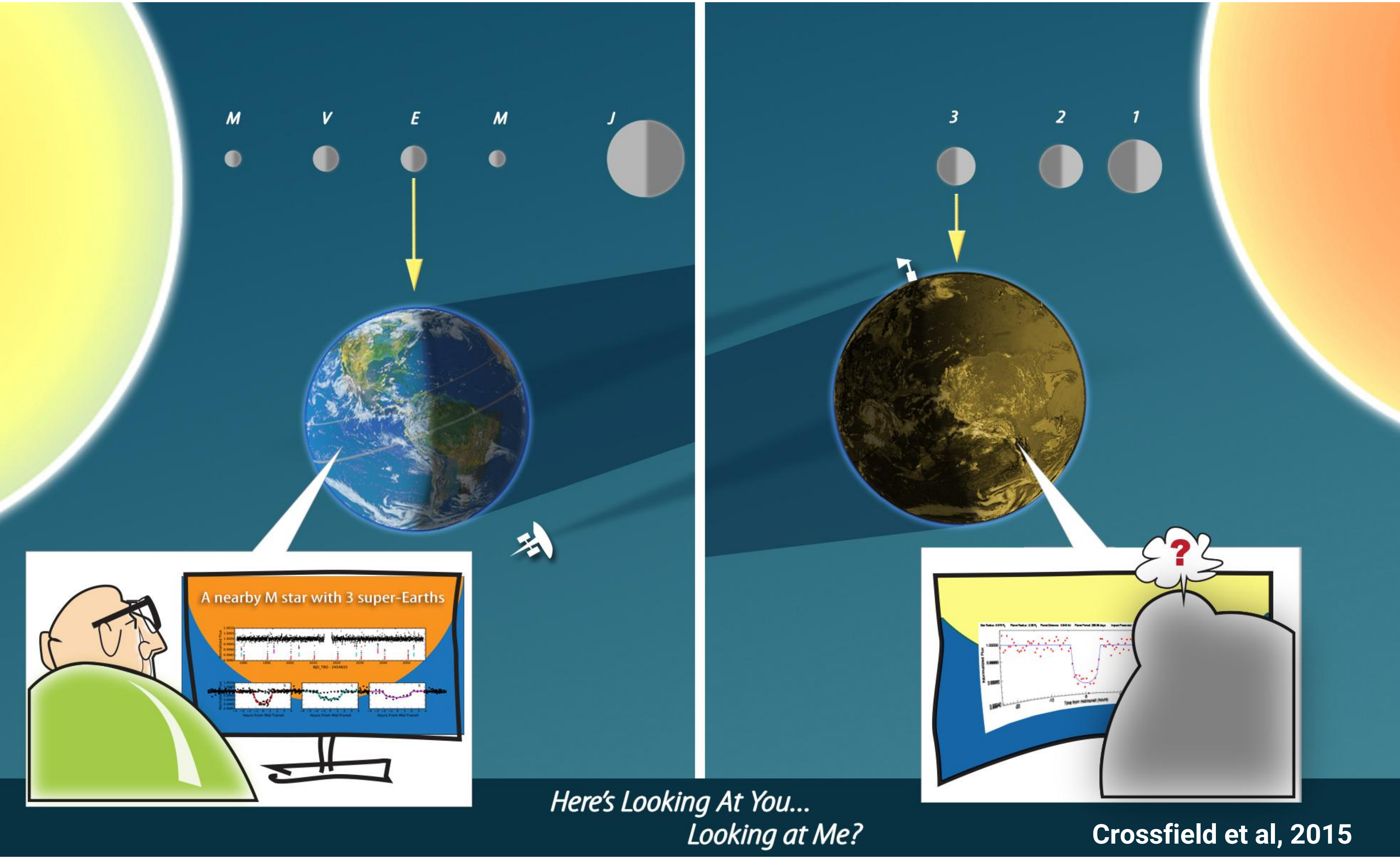
PROJECT PROPERTIES

MONTE-CARLO TRANSIT INJECTIONS

CANDIDATES

THEORY

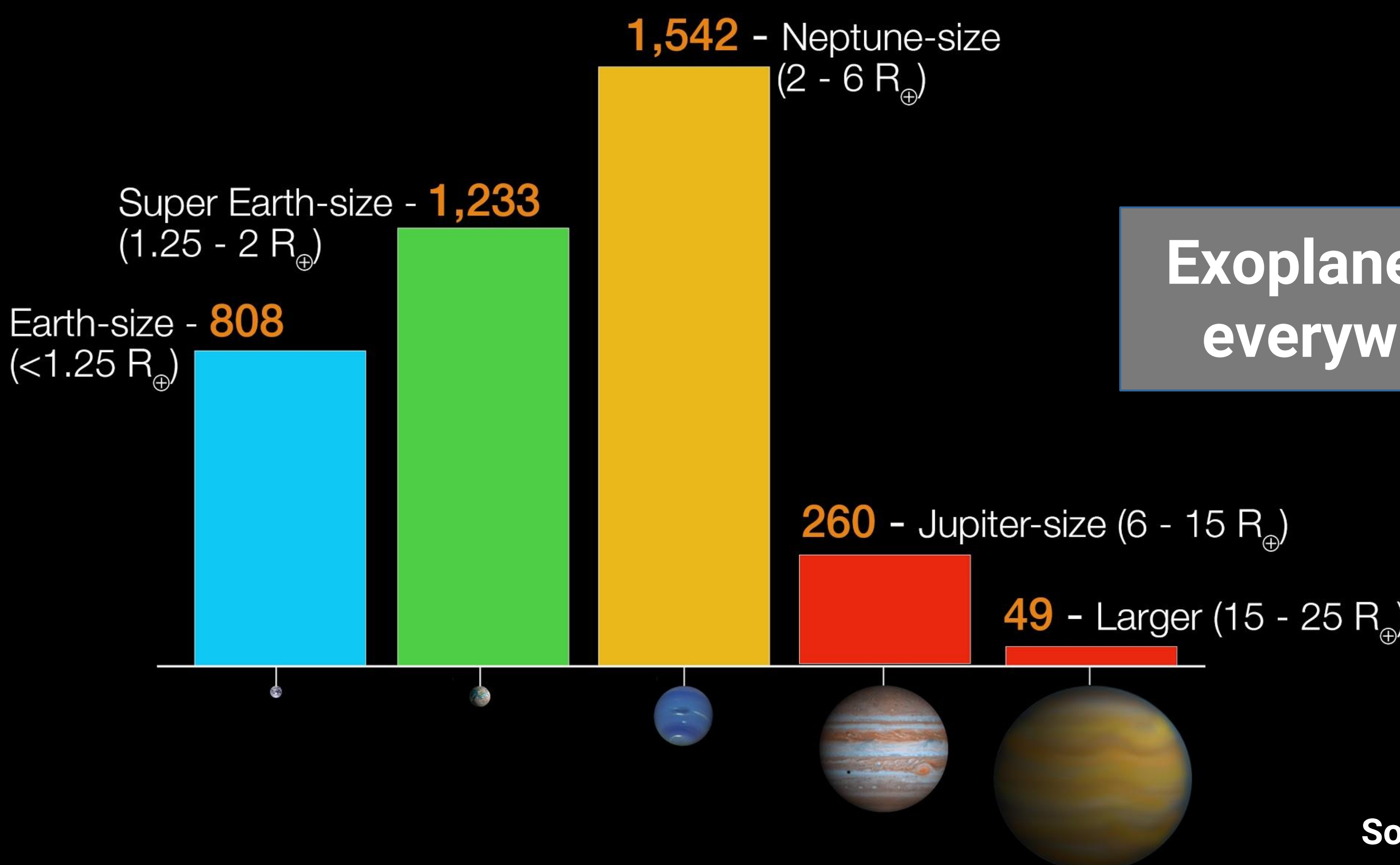
Exoplanets - the hot new field



Crossfield et al, 2015

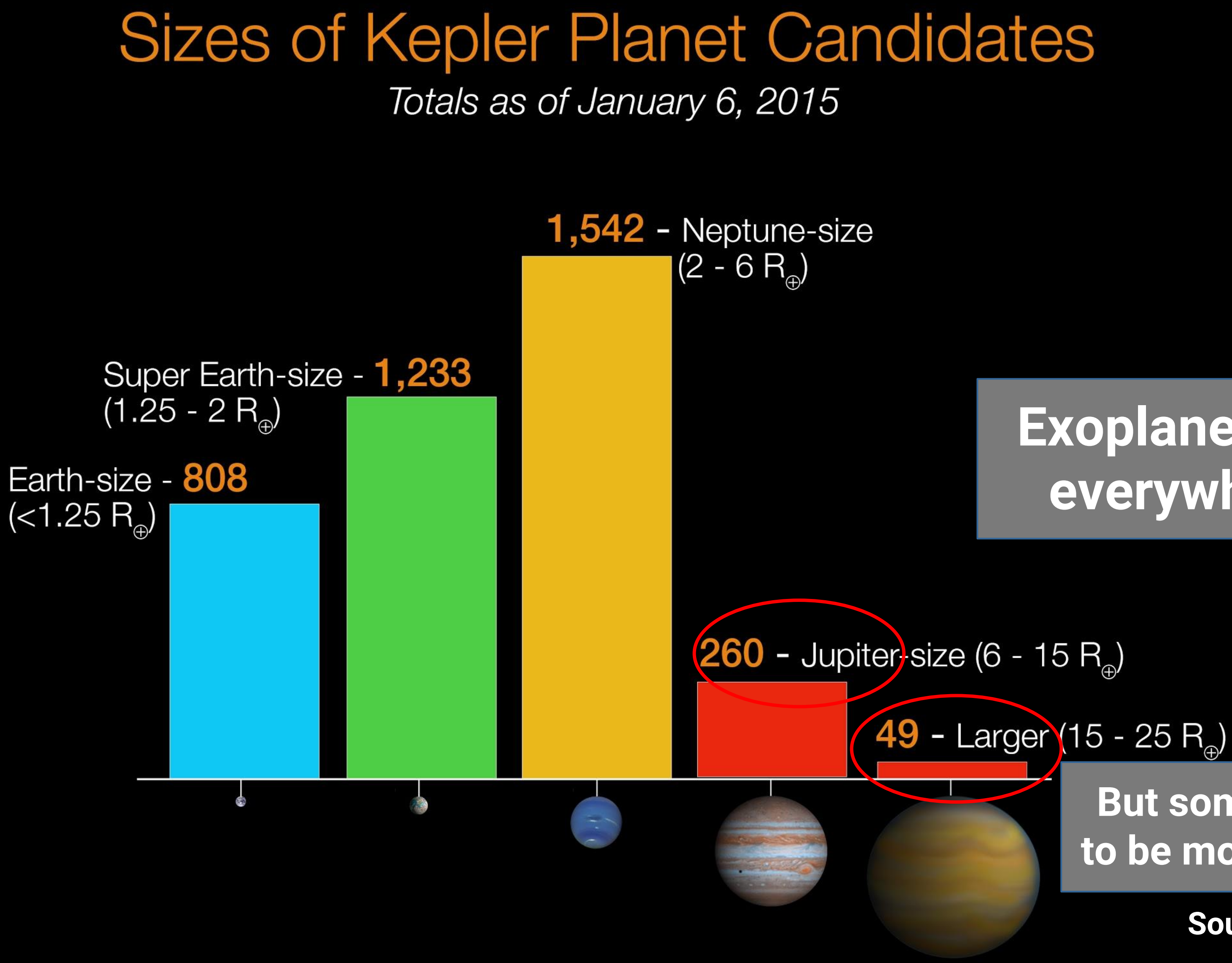
Sizes of Kepler Planet Candidates

Totals as of January 6, 2015



Exoplanets are everywhere!

Source: NASA



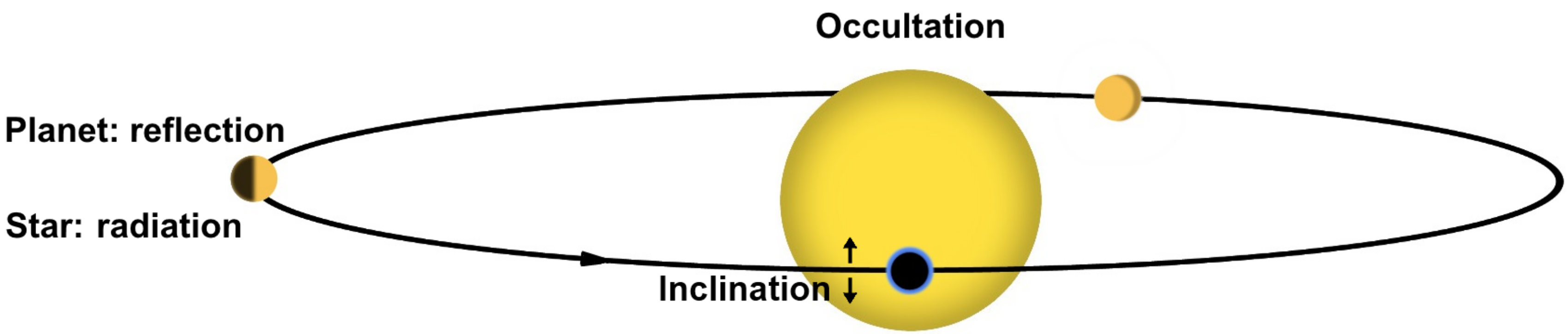
Exoplanets are everywhere!

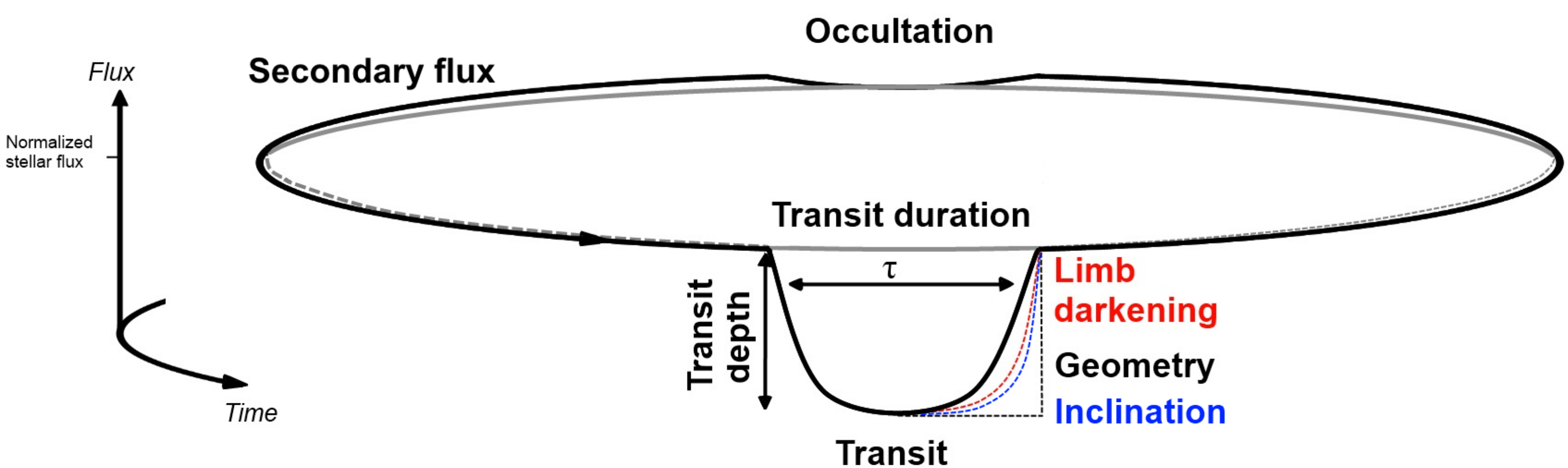
But some seem to be more rare...

Source: NASA

THEORY

How does transiting work?



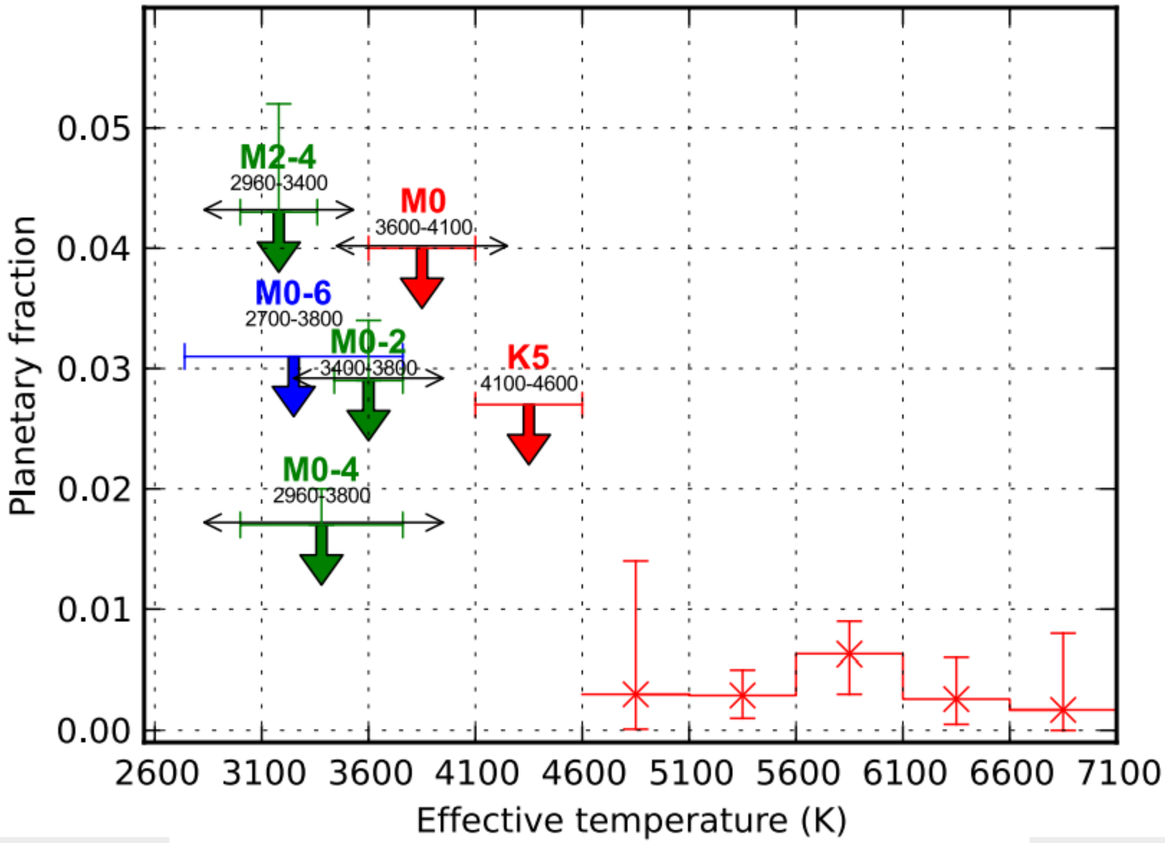


CONCEPT

Why have a small project?

Best candidates for transit spectroscopy

Planetary formation model unclear



Kovacs et al., 2013

Only small sample sizes in other surveys

Best candidates for transit spectroscopy

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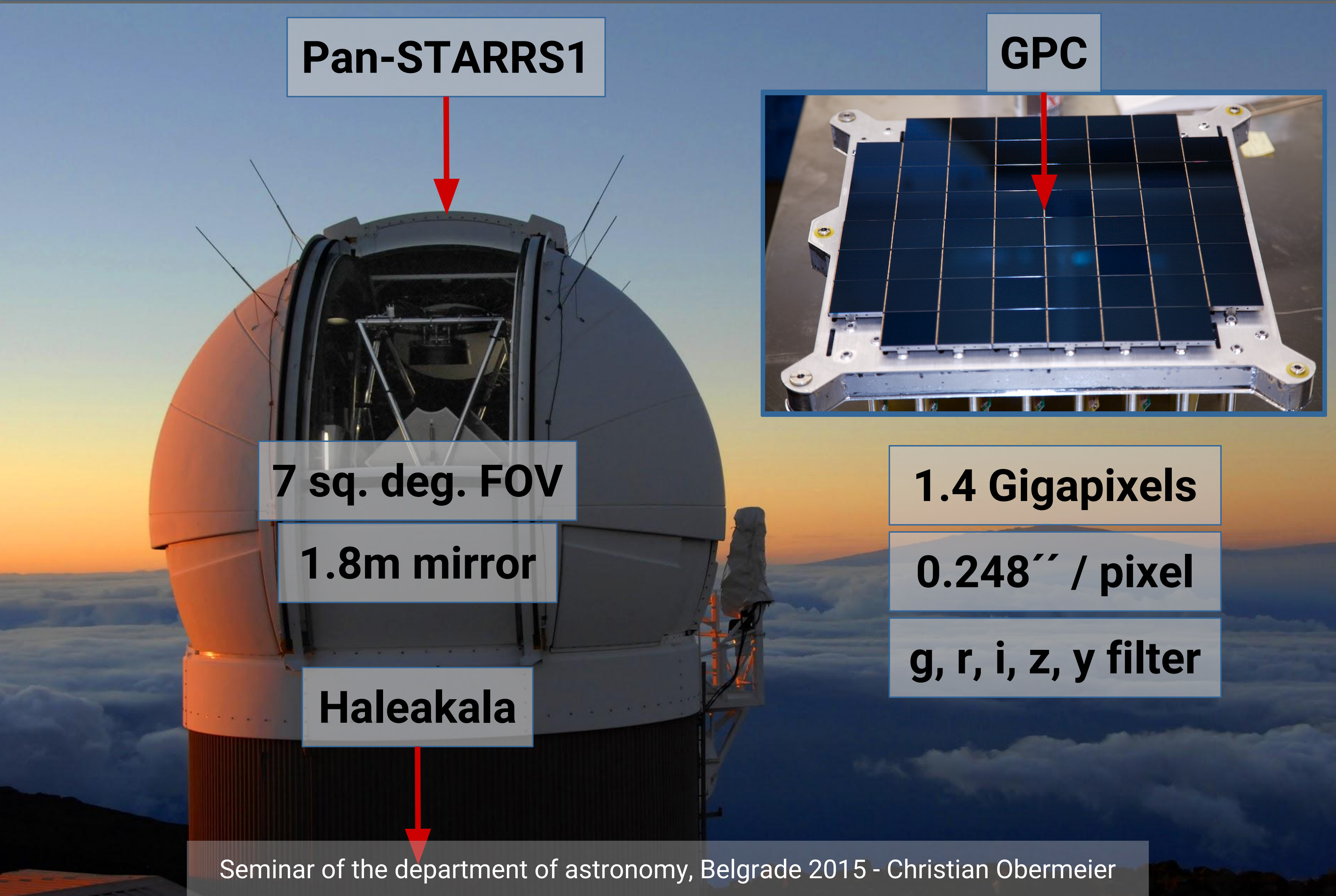
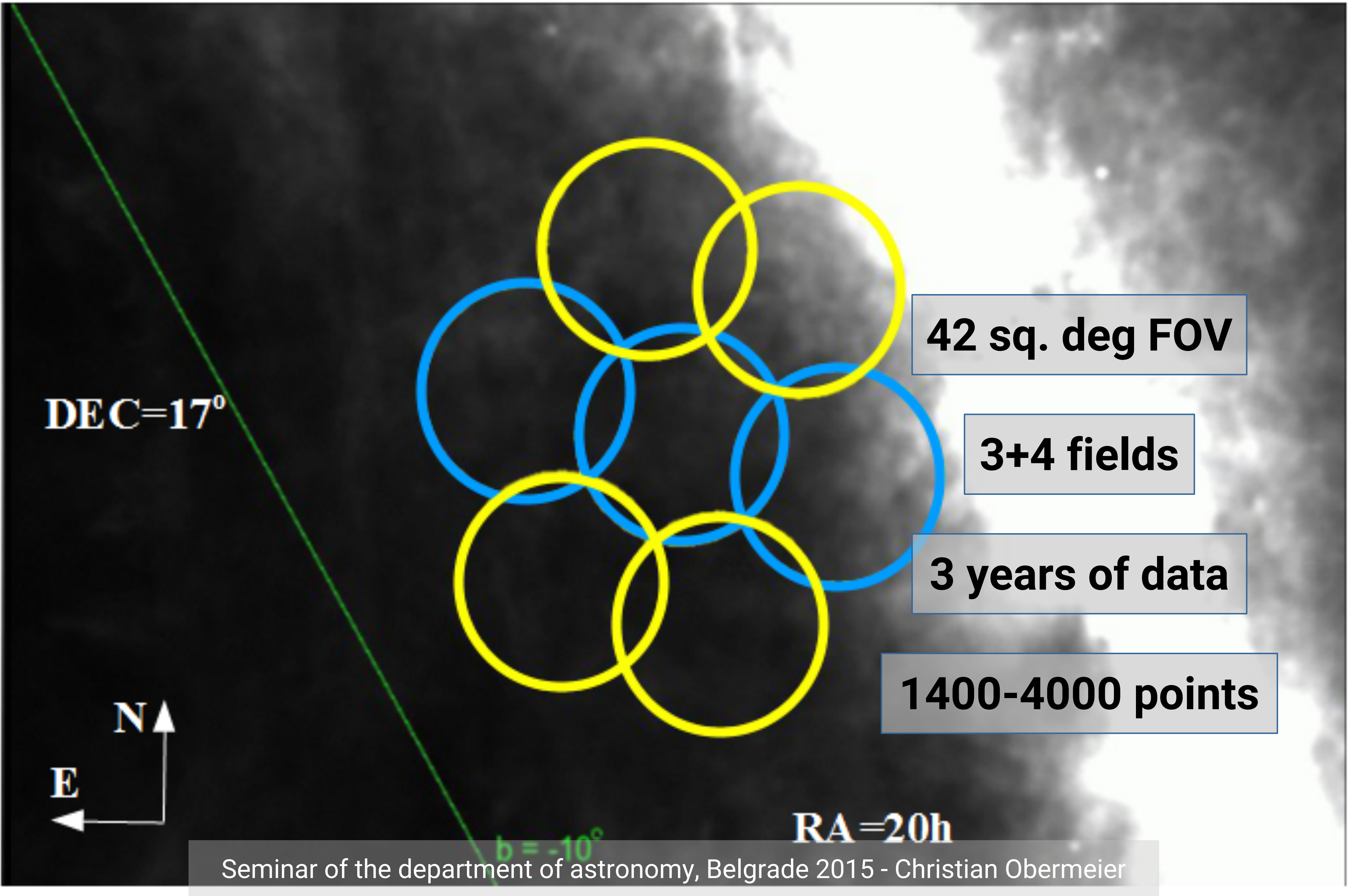

Pan-STARRS1
7 sq. deg. FOV
1.8m mirror
Haleakala
GPC
1.4 Gigapixels
0.248´´ / pixel
g, r, i, z, y filter

PROJECT



42 sq. deg FOV

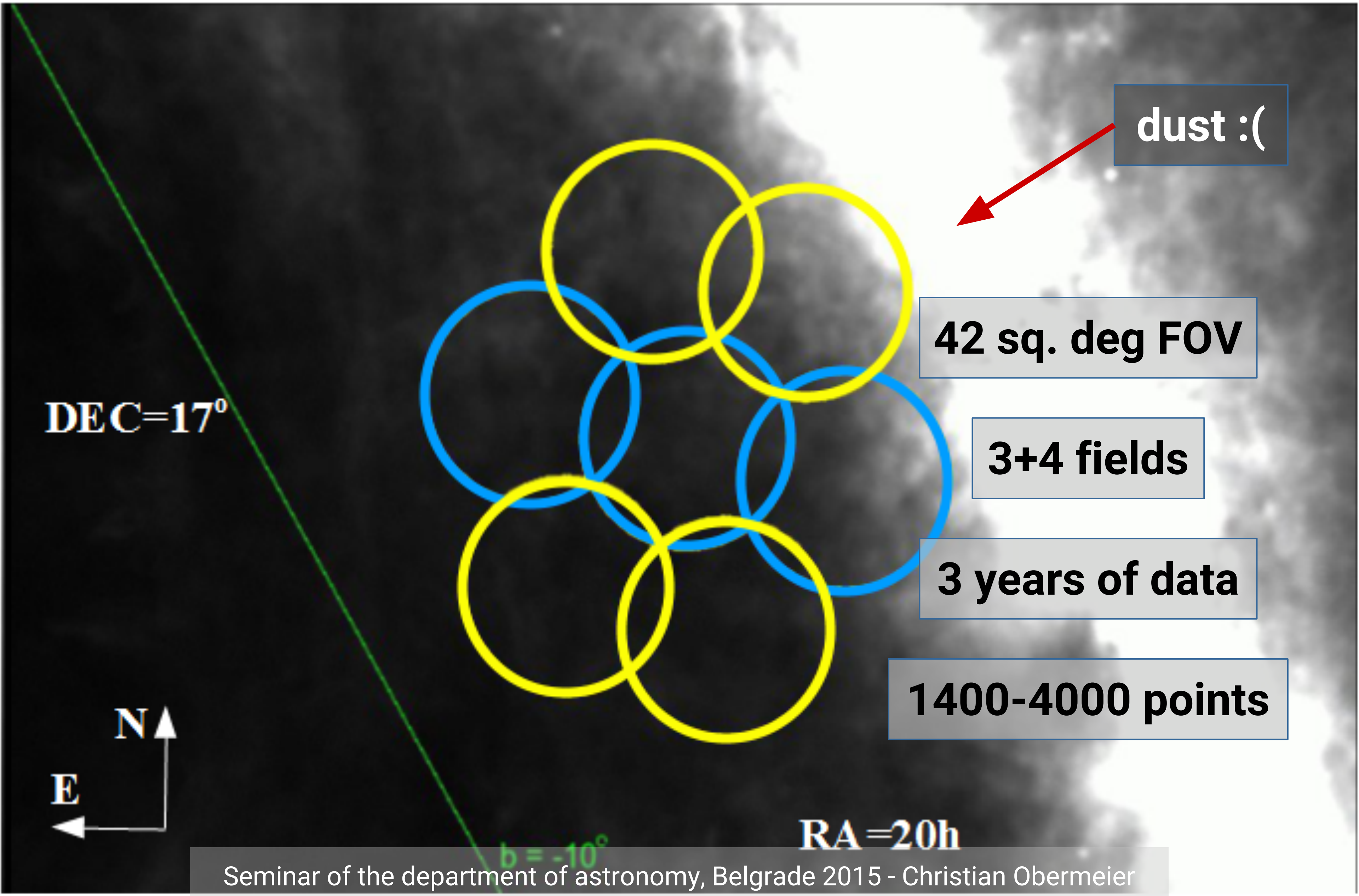
3+4 fields

3 years of data

1400-4000 points

PROJECT

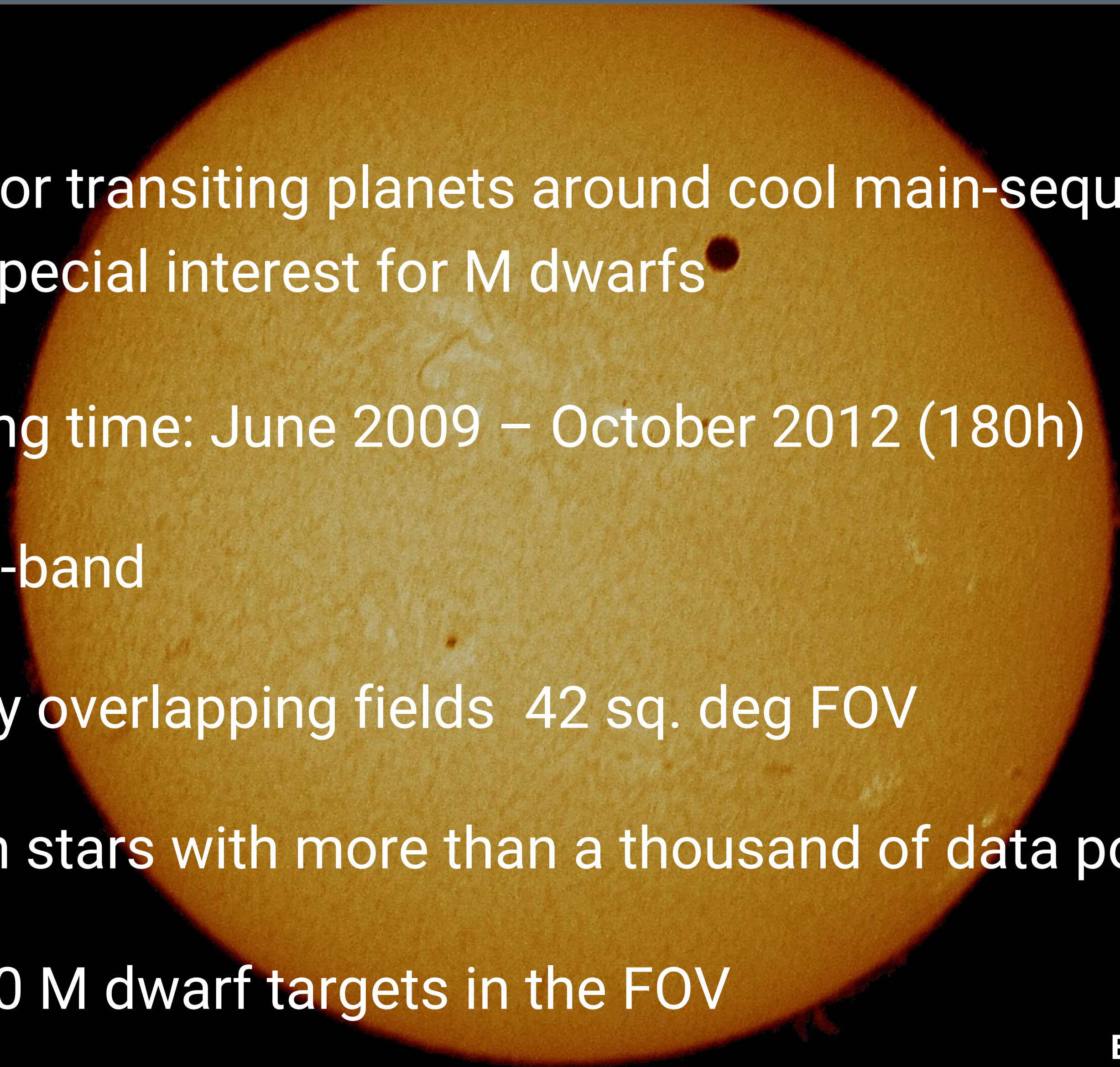
Pan-Planets



PROJECT

Pan-Planets

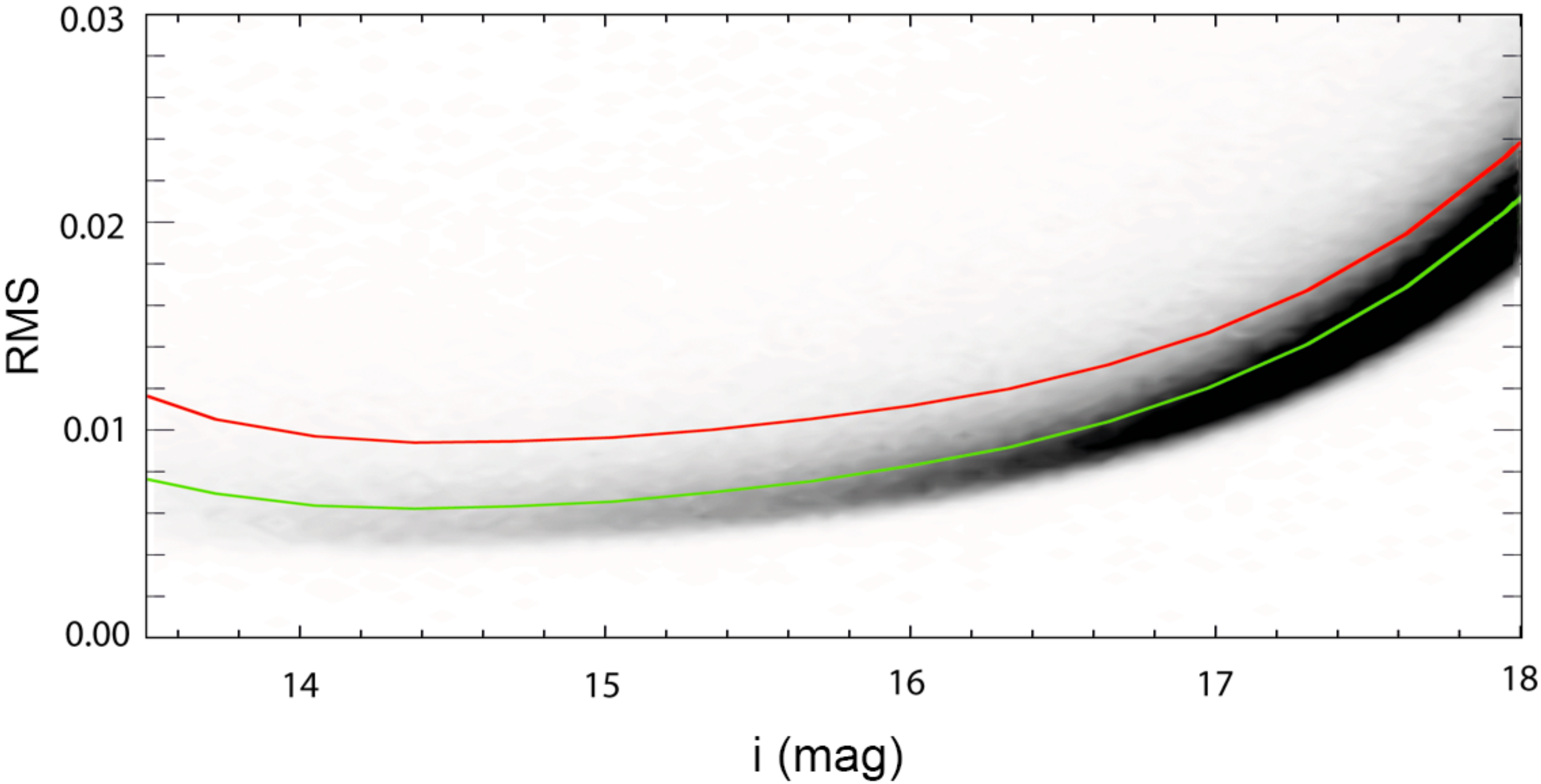
- Survey for transiting planets around cool main-sequence stars - special interest for M dwarfs
- Observing time: June 2009 – October 2012 (180h)
- Data in i-band
- 7 slightly overlapping fields 42 sq. deg FOV
- 4 million stars with more than a thousand of data points
- ~ 50.000 M dwarf targets in the FOV



ESA

PROJECT

Quality could be better....



Our goal

- Reliable selection of M dwarfs
- Remove red, distant giant stars
- Cope with varying amounts of extinction in the FOV

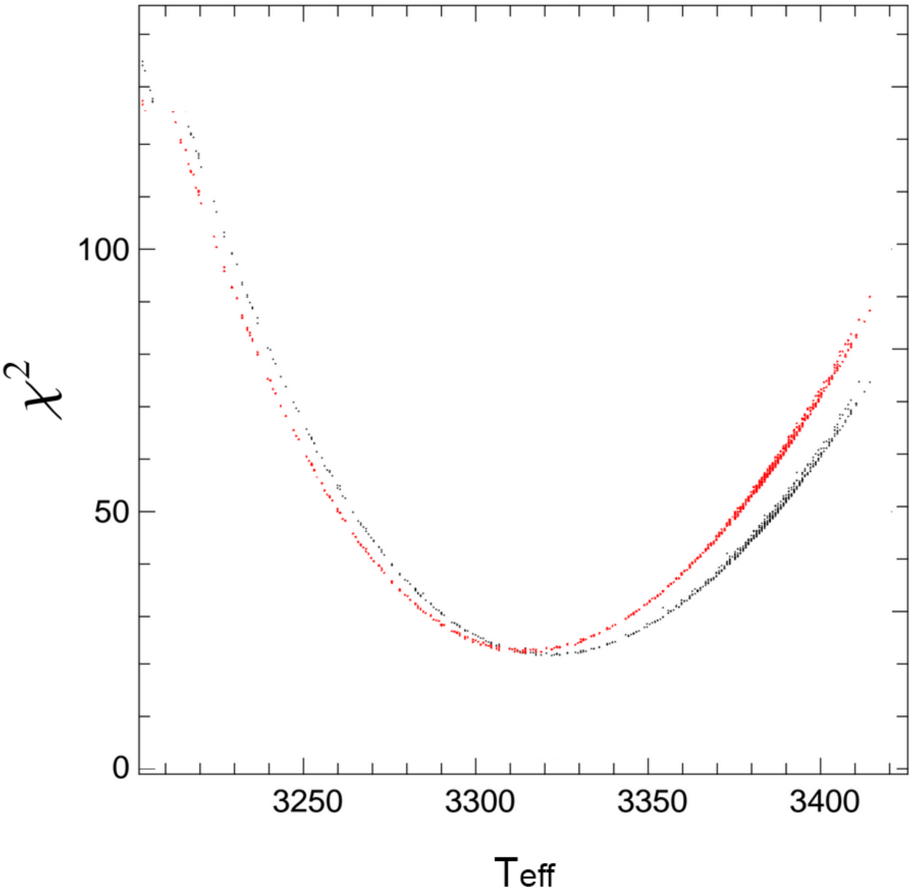
How we do it?

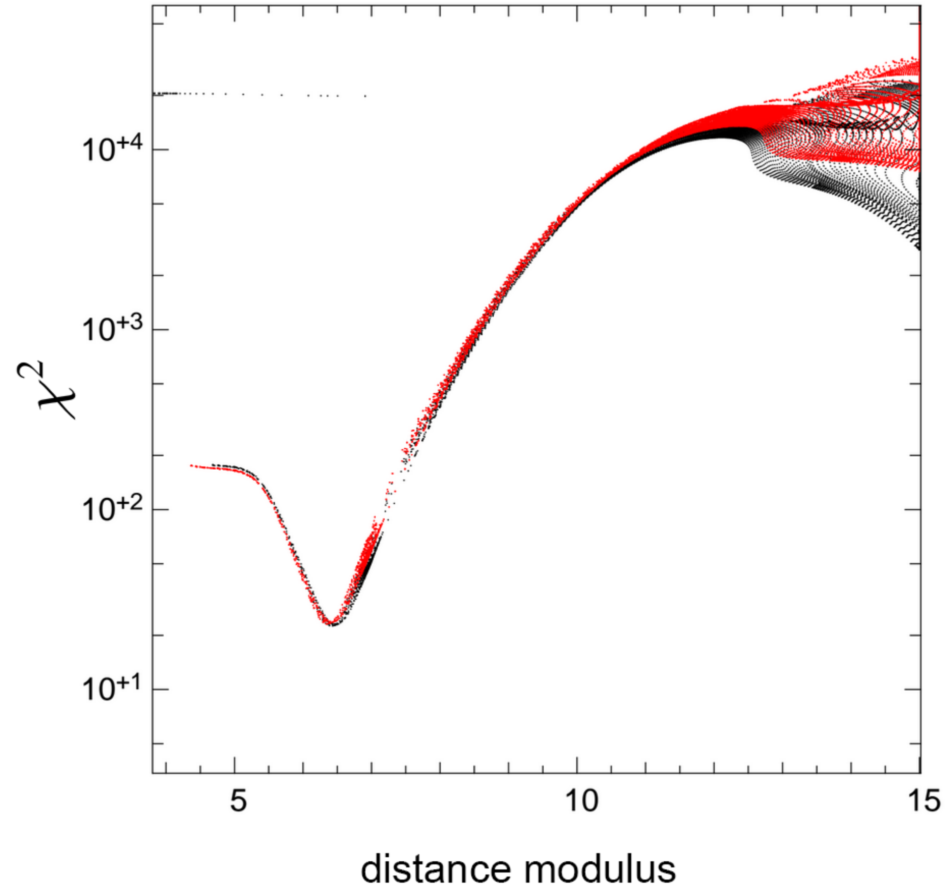
- SED fitting of PS1 griz+JHK (2MASS) magnitudes
- Using 6 different synthetic SED models
- Extinction fit $\rightarrow$ dustmap from Schlegel et al., 1998
- Proper motion cuts

Does it work?

- Yes! About 50.000 selected targets

Good host star characterization possible





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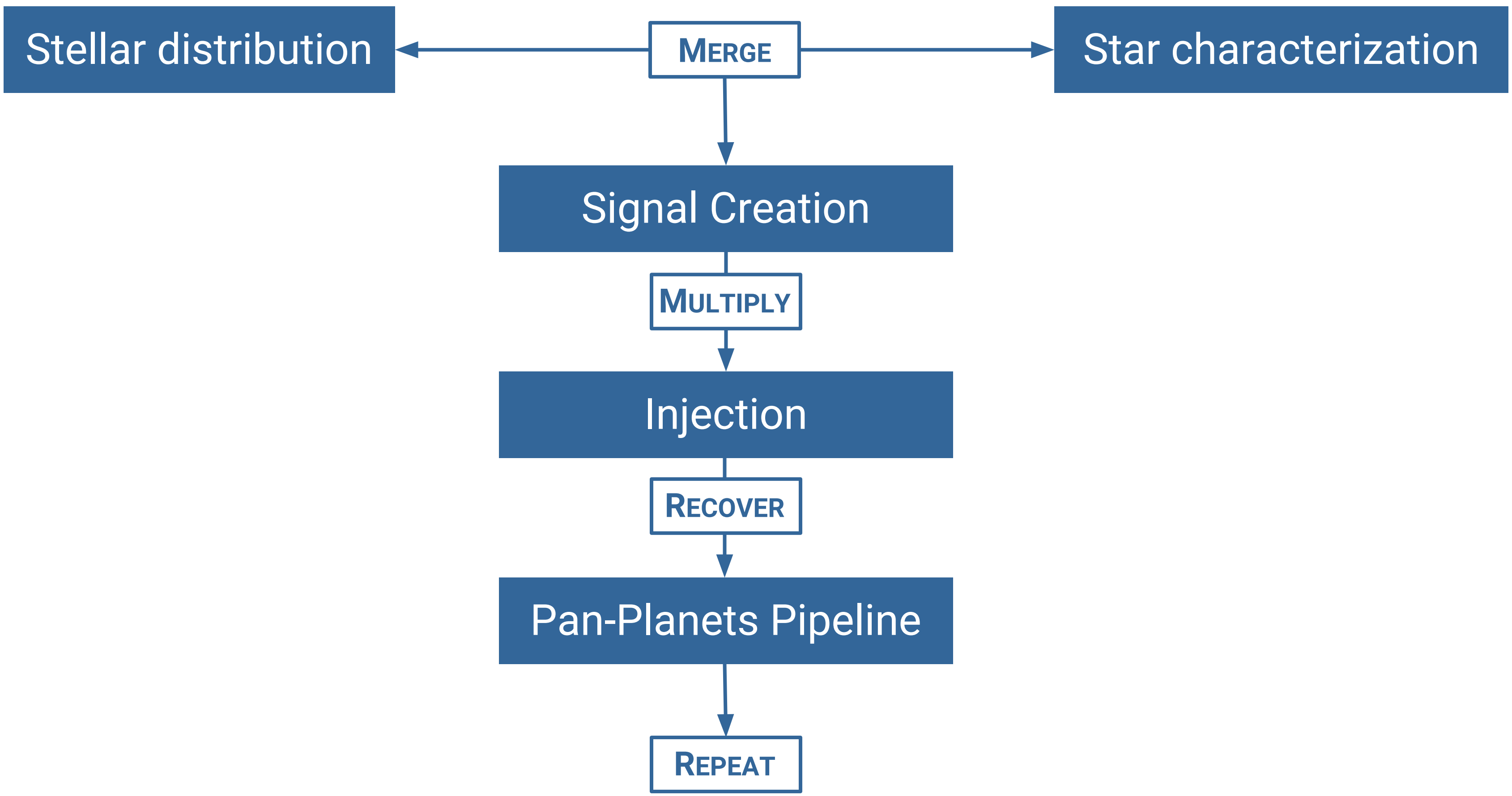
Our method - transit injections



Monte-Carlo Simulations

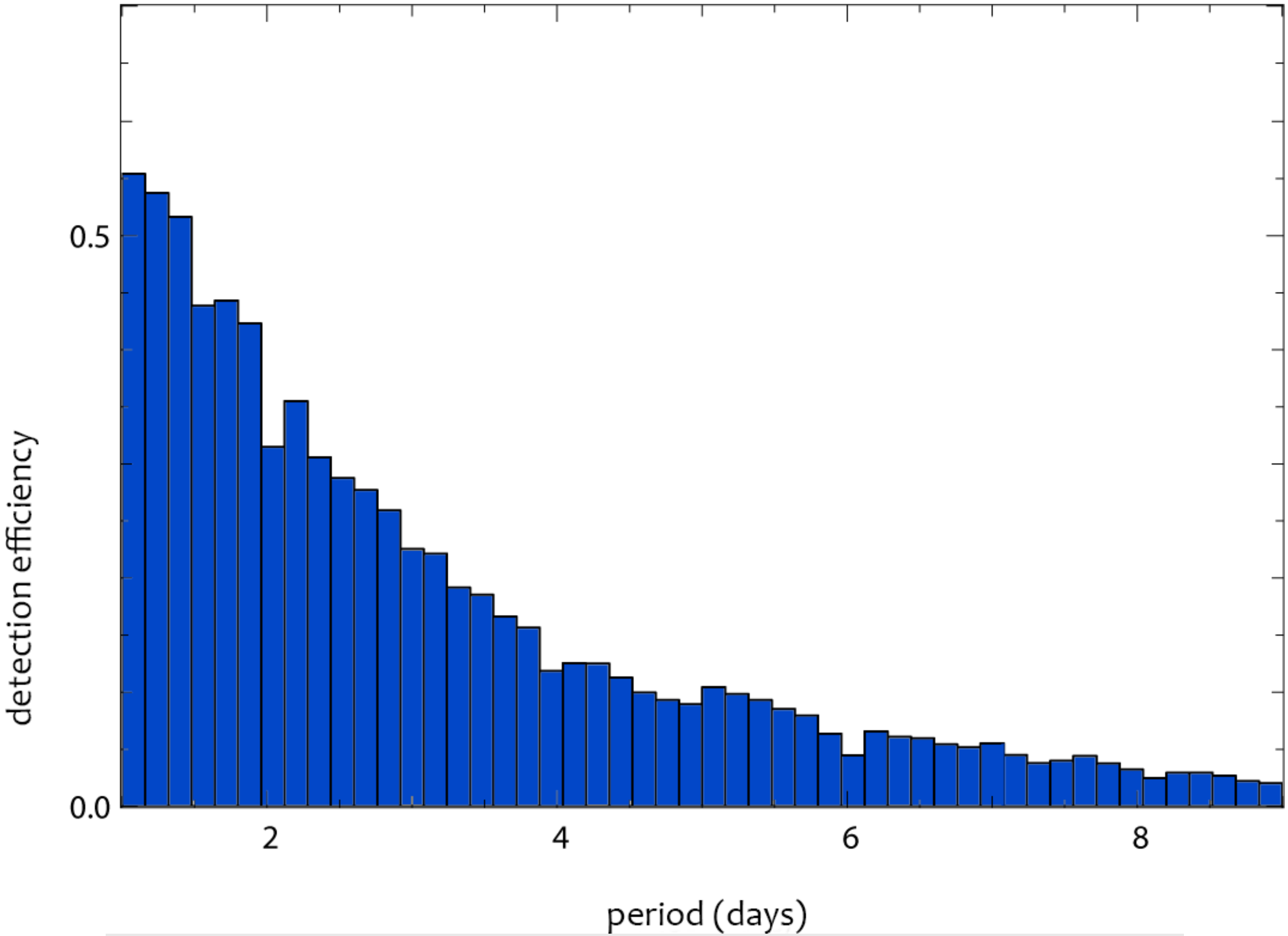
Results for M dwarfs

- Complete set of transit injections for all 50000 M dwarfs with 200 repetitions
- Detection efficiency of over 60% for 1d < p < 3d
- Lower efficiency of 15% for 3d < p < 10d
- Null result would mean: new upper limit of ~0.4%

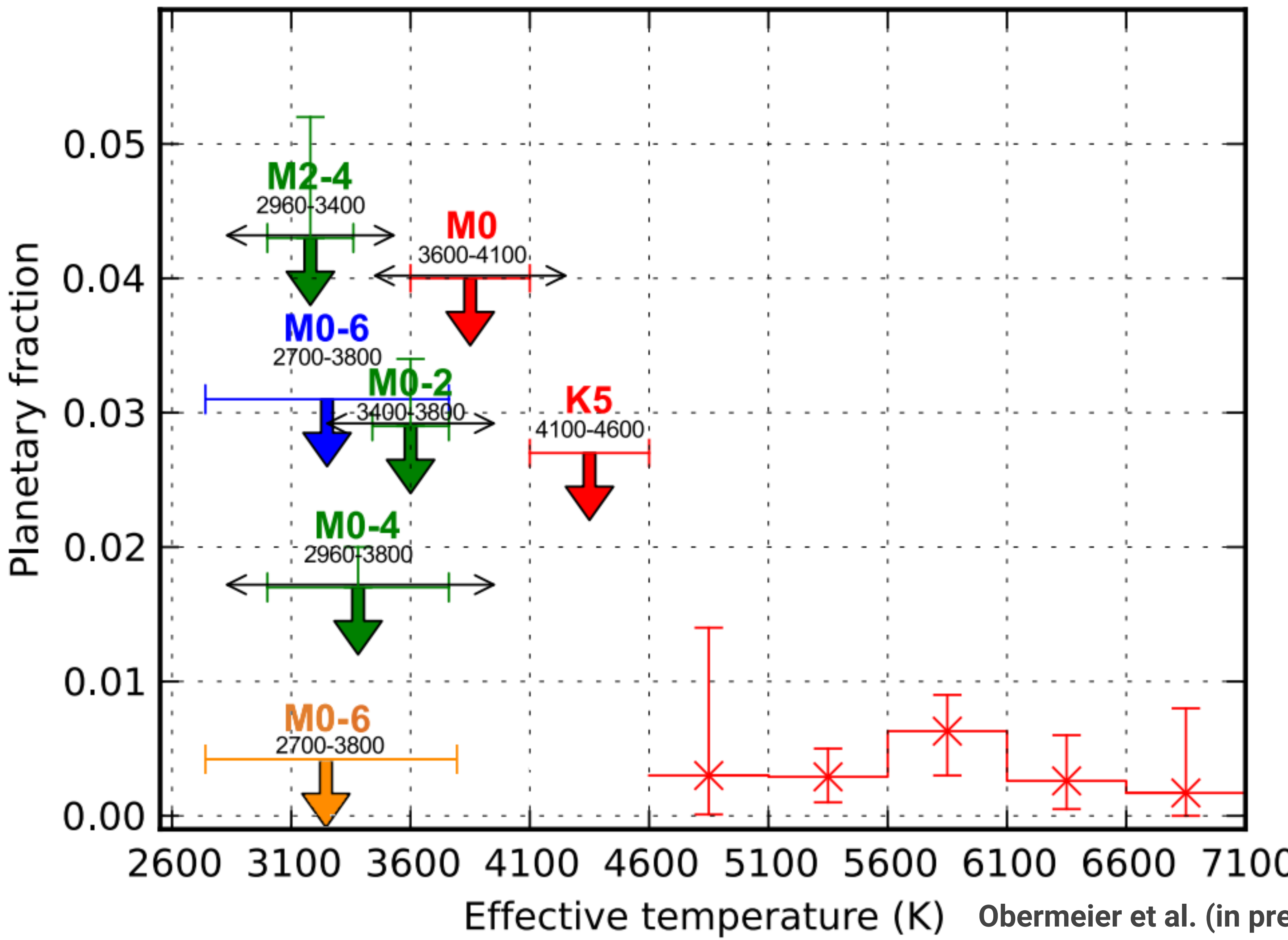
Results for other main-sequence stars

- Efficiency of 15% - 10% for 1d < p < 3d
- We expect to find one Hot Jupiter per field

Monte-Carlo Simulations M dwarf sensitivity



MONTE-CARLO SIMULATIONS New fraction limits

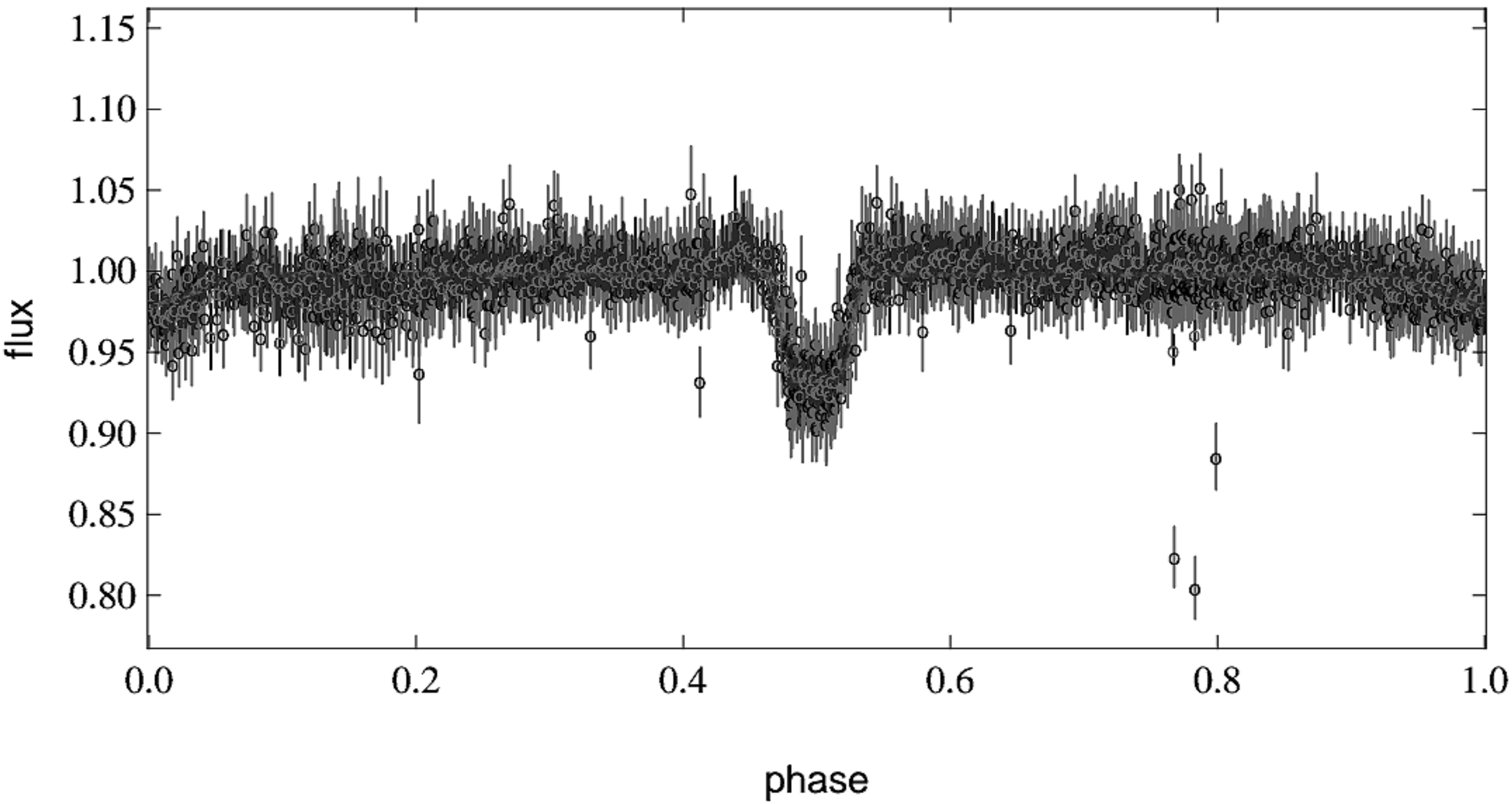


Obermeier et al. (in prep.), 2015

MONTE-CARLO SIMULATIONS

Real sample

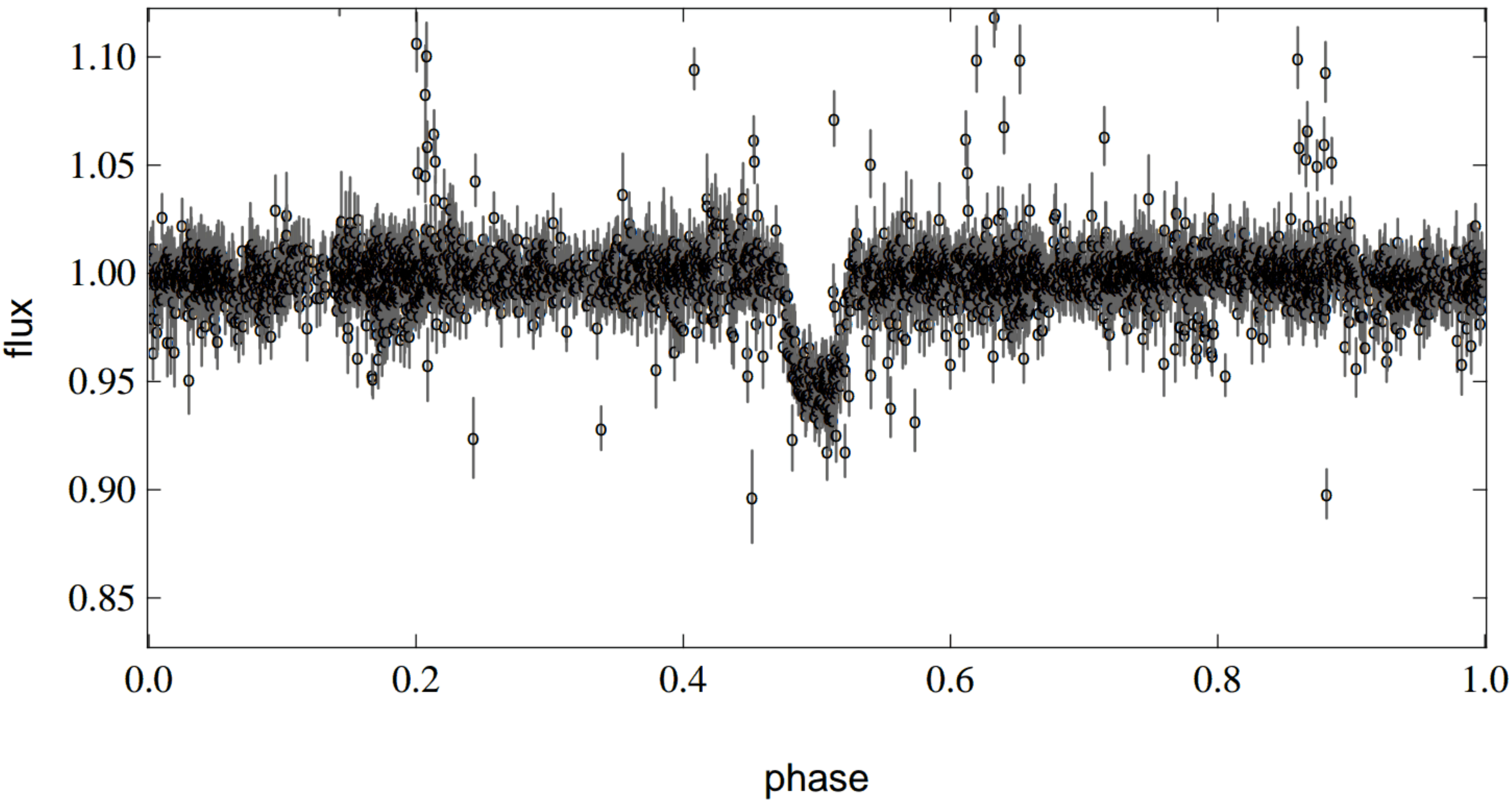
Confirmed brown dwarf + M dwarf system



Confirmed 16th mag M dwarf system with p = 0.74 d

MONTE-CARLO SIMULATIONS Simulated sample

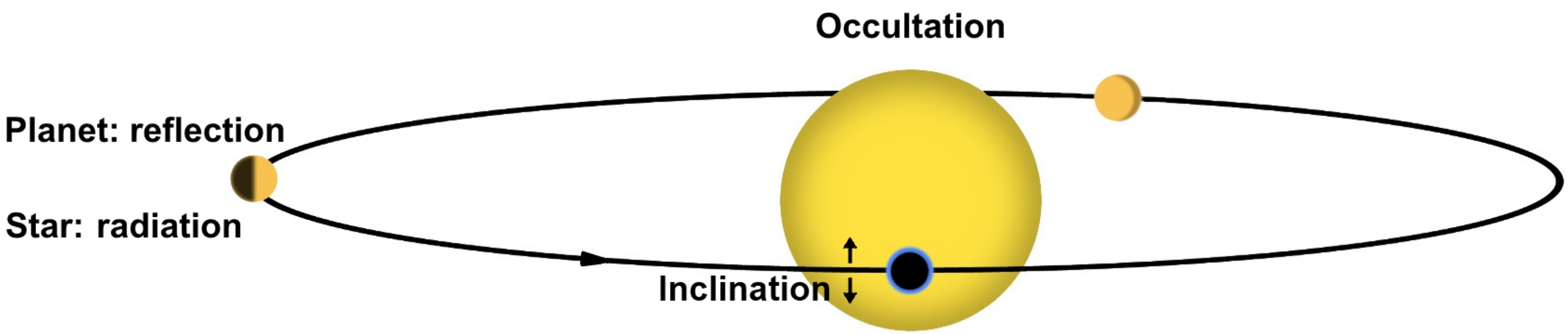
Simulated Hot Jupiter around an M dwarf

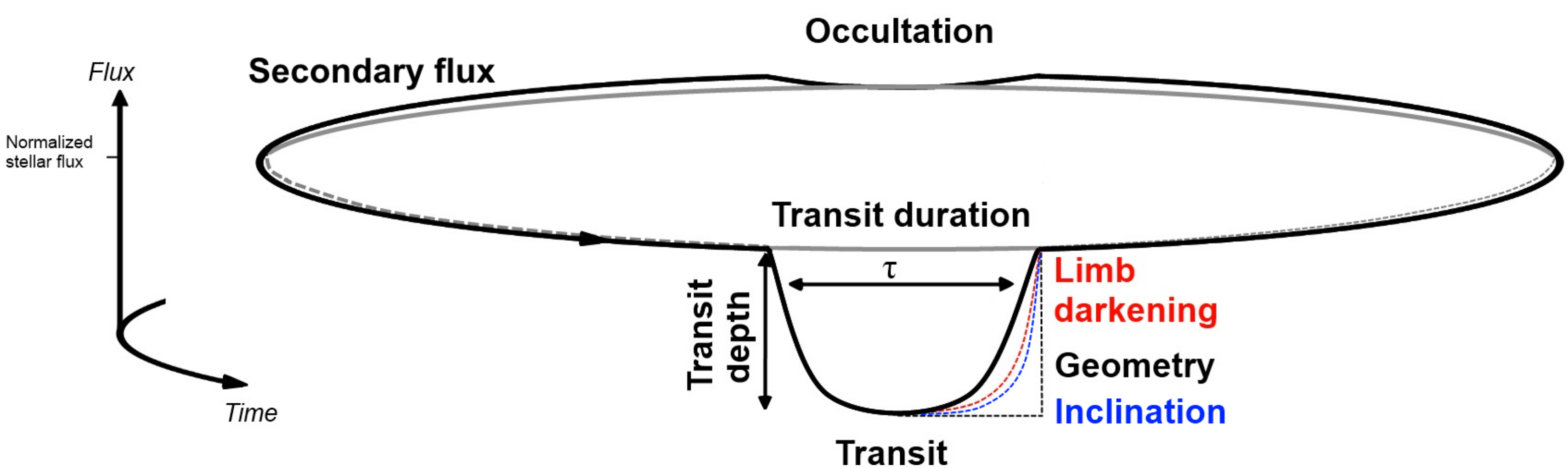


Simulated HJ around a 17th mag M dwarf with p = 1.07 d

THEORY RECAP

How does transiting work?





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What we start with:

- Stars characterized with SED fitting + proper motion
- V-fitting algorithm used for period detection

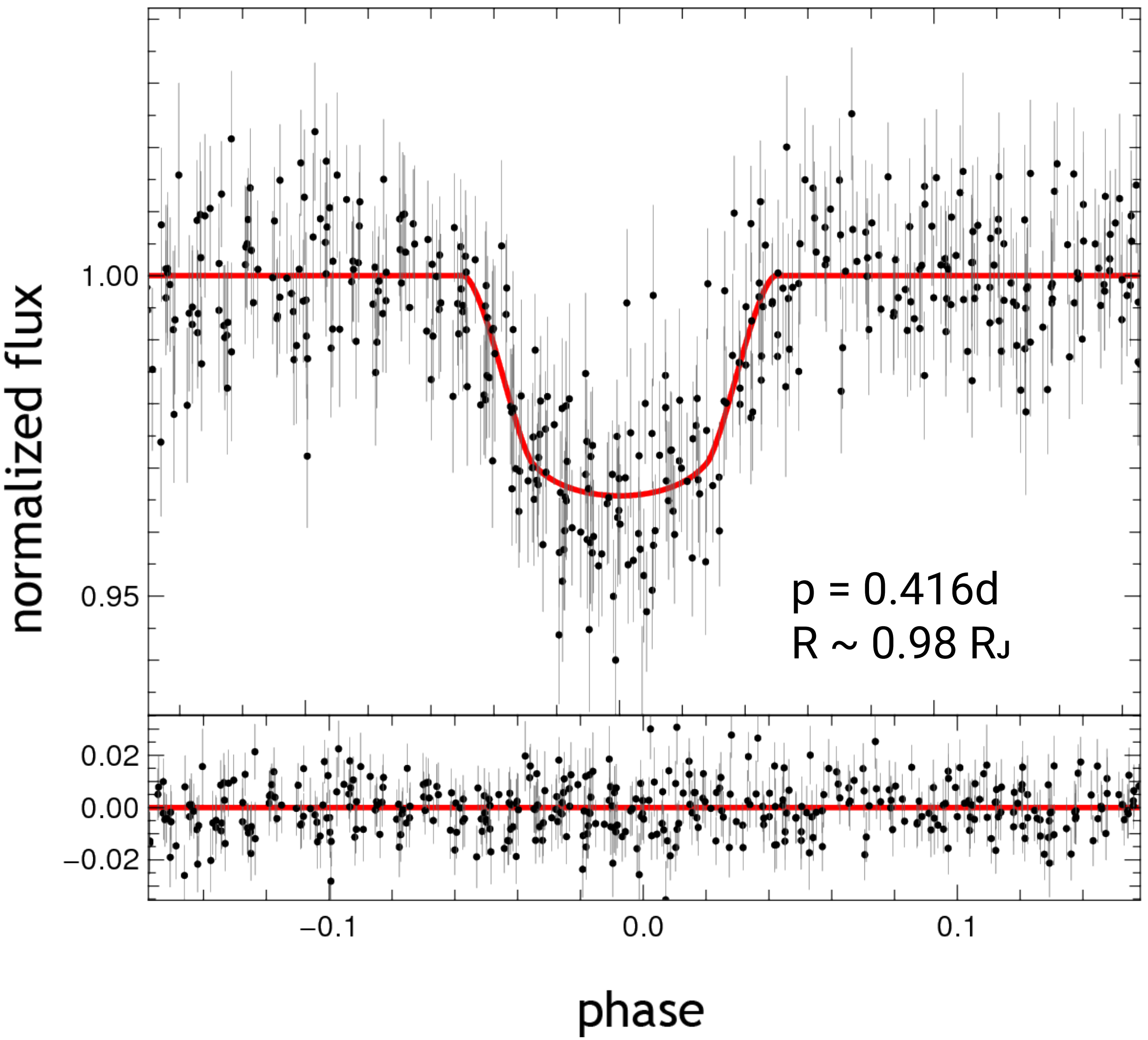
More precise refitting with MCMC:

- Priors from SED fitting (radius, limb darkening)
- Priors from BLS fitting (transit duration, depth, period, t0)
- Determine best-fitting properties+errors

What we have:

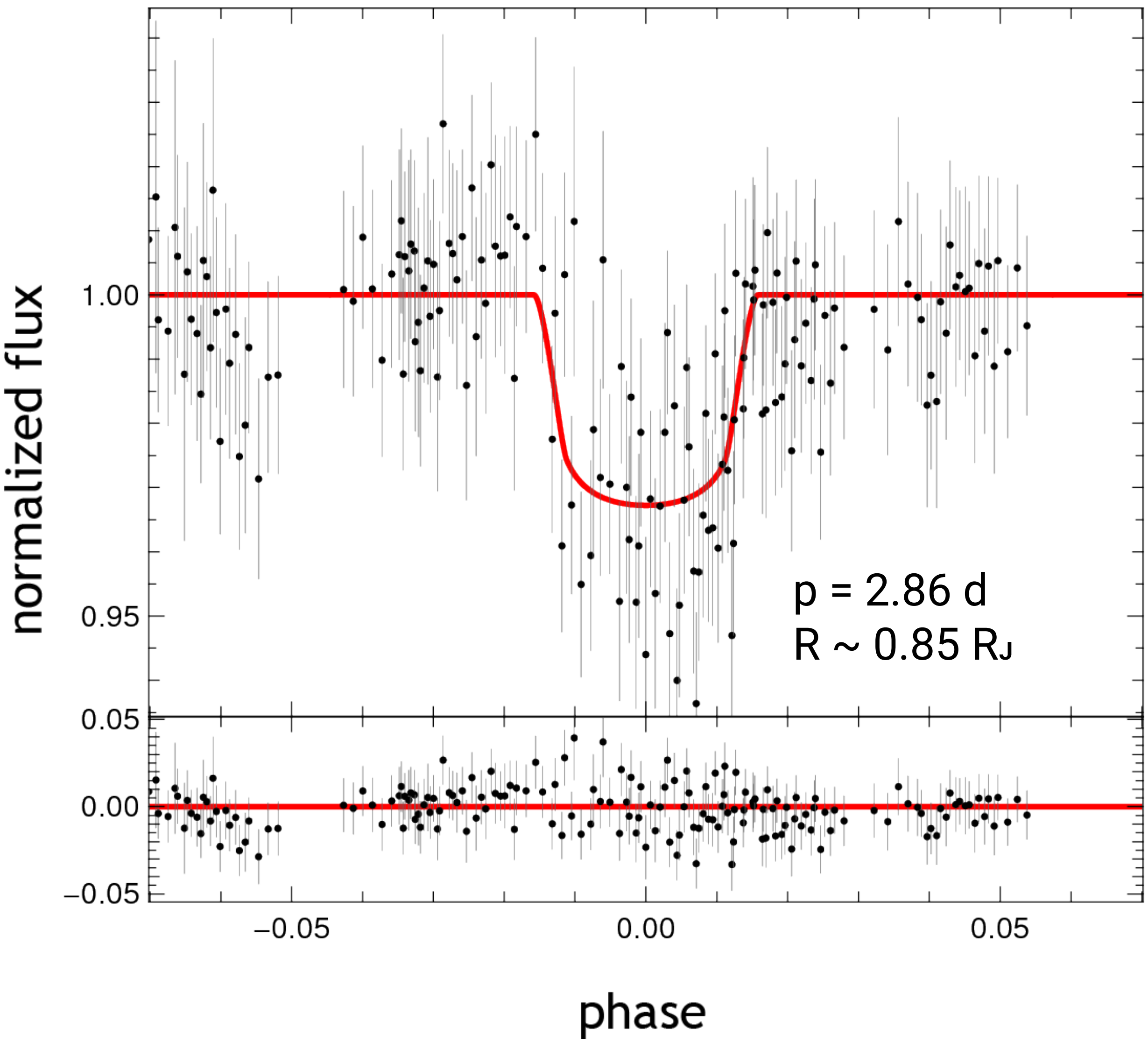
- ~10 M dwarf Hot Jupiter candidates
- ~15 K, G, F dwarf Hot Jupiter candidates
- ~200 M dwarf eclipsing binaries
- ~15 white dwarf variable objects

CANDIDATES M dwarf Hot Jupiter candidate



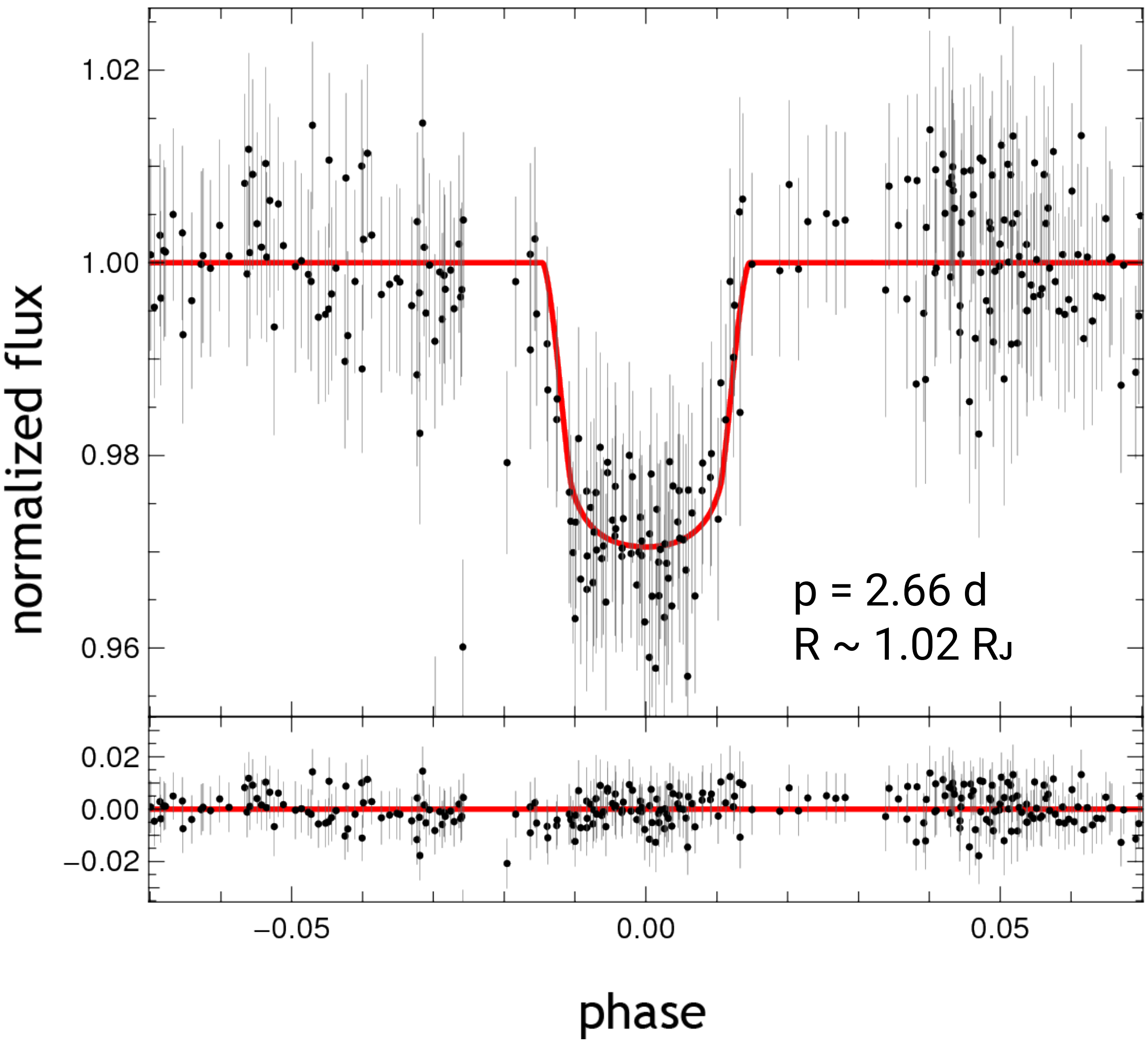
CANDIDATES

M dwarf Hot Jupiter candidate



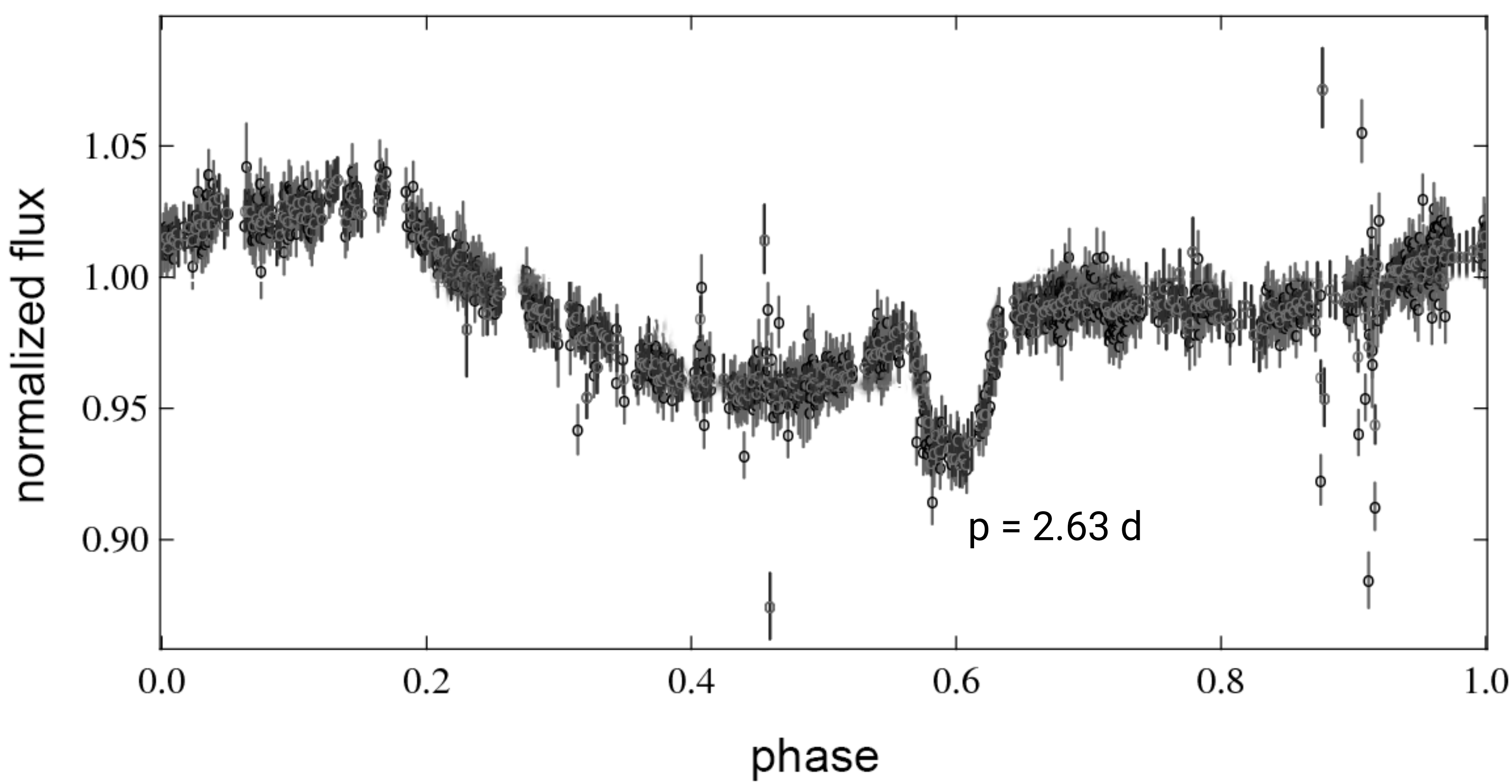
CANDIDATES

K dwarf Hot Jupiter candidate



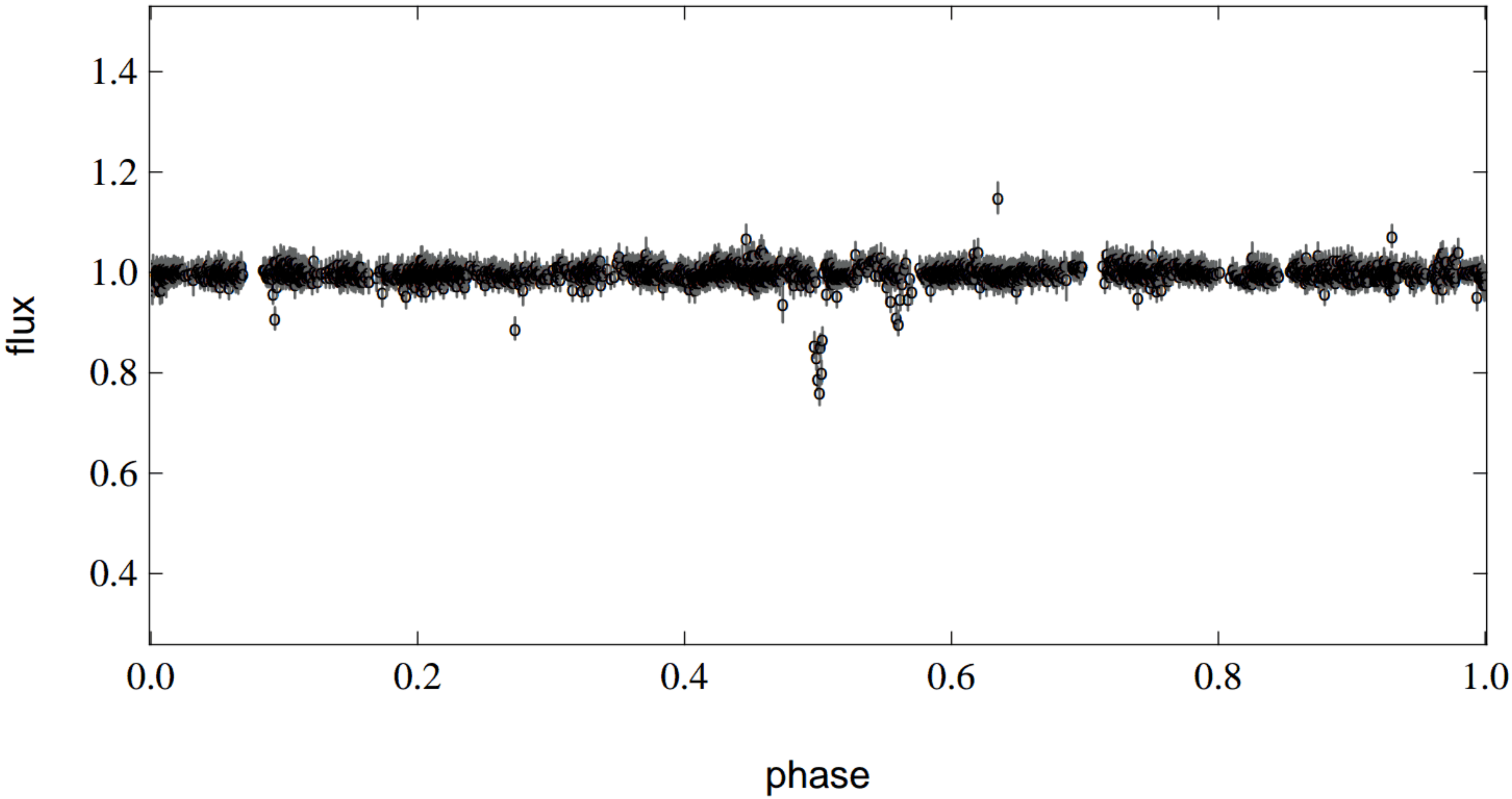
CANDIDATES

Curious variable object



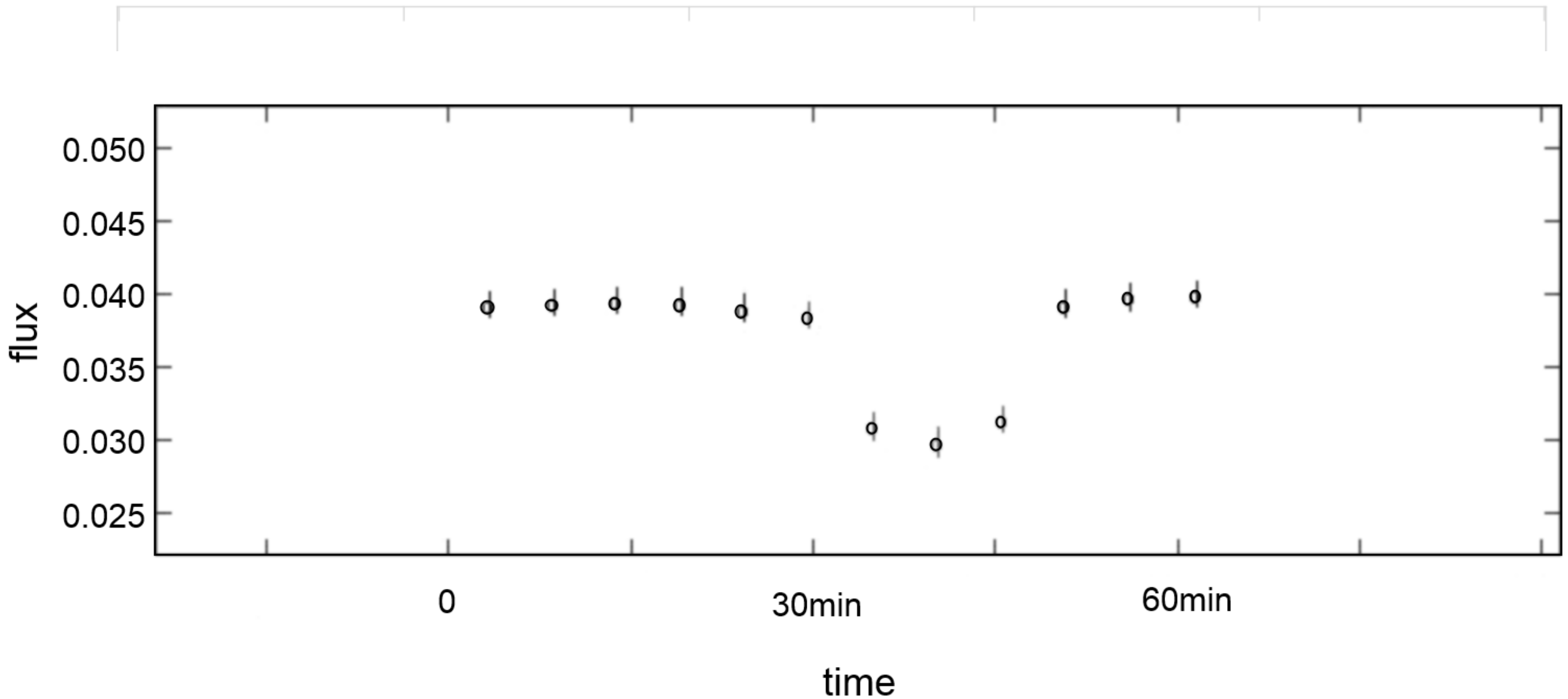
Transit-like event in a variable 14th mag system

CANDIDATES Possible white dwarf planetary transit



Sharp transit event in a 16th mag white dwarf

CANDIDATES Possible white dwarf planetary transit



Complete transit features visible!

phase

Sharp transit event in a 16th mag white dwarf

How will we follow up candidates?

- 10 nights at McDonald observatory (Texas)

  → Reconnaissance LRS, possible RV measurement
- ~14 nights at SpeX, IRTF (Hawaii)

  → Dedicated LRS/MRS for eclipsing M dwarf binaries
- ~20 nights at Wendelstein (Bavaria)

  → Confirm periods

  → Rule out false detections (red noise residuals)

  → Improve transit shape estimate

  → Record different bands

Conclusion

- Pan-Planets is capable of detecting Hot Jupiters
- We will more accurately assess the occurrence rate
- We received time to follow up all candidates
- Next months: finish follow-up phase
- Publish!